I. History of Chemical Regulation

In the United States, the primary legislative framework regarding chemical use is the Toxic Substances Control Act (TSCA), which was passed into law in 1976. The two main objectives of the law are to (1) assess and regulate new commercial chemicals by requiring a premanufacture notice (PMN) listing the chemicals production volume, uses, exposures, and environmental fate, to "the extent it is known to or reasonably ascertainable by the submitter" and to (2) regulate the distribution and use of then existing chemicals that pose an, "unreasonable risk to health or to the environment."

This law, though good intentioned, is widely recognized by the U.S. Government Accountability Office, the U.S. Environmental Protection Agency, etc. as ineffective at allowing regulatory agencies to assess hazardous traits of a majority of commercial chemicals and to control chemicals of significant concern. Wilson et al identified two major flaws with TCSA as follows: When TCSA was passed into law in 1976, the 62,000 chemicals in commercial use at the time were "grandfathered in" and assumed to be safe unless the EPA could prove otherwise, but in order to assess the risks of existing chemicals, the EPA needed hazard and exposure data that producers were not required to provide (unless the EPA could first show that the substance presented an unreasonable risk to human health or the environment)

This "Catch 22" situation has severely restricted the EPA's jurisdiction. "In the first 15 years under TSCA, the agency was able to review the risks of about 1,200 (2%) of the 62,000 existing chemicals, despite the fact that the agency estimated that about 16,000 (26%) were potentially of concern based on their production volume and chemical properties" [3]

Many agencies are pushing for a reform of this law and in response, the Chemical Safety Improvement Act and the TSCA Modernization Act of 2015 have been drafted, but policy makers remain largely divided on the best way to reform TSCA. As a result, these acts have been stalled in Congress.

Let's be clear, however, that valiant efforts are being made domestically and abroad to address the issue of chemical regulation.

- The Environmental Protection Agency (EPA), Food and Drug Administration (FDA), the National Center for Advancing Translational Sciences (NCATS) and the National Toxicology Program at the National Institute for Environmental Health Sciences (NIEHS) are collaborating on a high throughput screening process to identify chemicals that have a potential to cause human health to flag for further investigation. [5]
- In 2006 Europe ushered in a regulatory framework called "REACH," (Registration, Evaluation, Authorization, and Restriction of Chemicals) that shifts the "burden of proof" of identifying a chemicals potential harm from government agencies onto industry. [6]

Sources:

[1] "EPA." Summary of the Toxic Substances Control Act. EPA, 9 Mar. 2015. Web.
[2] Stephenson, John B. "Chemical Regulation: Actions Are Needed to Improve the Effectiveness of EPA's Chemical Review Program." U.S. GAO -. GAO, 2 Aug. 2006. Web.
[3] Wilson, Michael P., and Megan R. Schwarzman. "Toward a New U.S. Chemicals Policy: Rebuilding the Foundation to Advance New Science, Green Chemistry, and Environmental Health."Microform & Digitization Review 41.1 (2012): Aug. 2009. Web.
[4] Mergel, Maria. "Toxic Substances Control Act (TSCA)." - Toxipedia. 23 Mar. 2011. Web.

[5] "Toxicology Testing in the 21st Century (Tox21)." EPA. EPA, Web.
[6] "REACH - Chemicals - Environment - European Commission." European Commission. 09 Aug. 2015. Web.

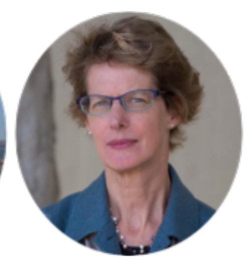
Policy change through government is often slow due to bureaucratic red tape, however government is not the only player in a chemical's life cycle. To better understand our problem space, we talked to experts about triclosan specifically, but what we learned shed light on the complexities of the issue of chemical regulation in general, as well as the need for a thoughtful, nuanced approach.

II. Talking to Experts

We started exploring our problem space by better understanding how triclosan, and other chemicals, are regulated and monitored at the waste-water treatment plant level. After all, wastewater treatment plants handle most household and city runoff in urban areas where triclosan use is thought to be highest. This engineered chokepoint in the release of triclosan into the broader environment seemed like an ideal place to intervene. What we ultimately learned, however, shifted our focus and some of our design criteria.

We approached **Michael Fan**, the manager of the UC Davis wastewater treatment plant to explore the potential use of a biosensor at his and other wastewater treatment facilities. Michael Fan was interested in exploring the idea, but essentially told us, “no legislation, no market.” Almost no waste water treatment plants are currently required to measure triclosan specifically in their effluent and none are likely to do so until it is required through legislation.

In talking to **Dr. Jay Davis** and **Meg Sedlak,** researchers from the **San Francisco Estuary Institute** (SFEI), one of California’s premier aquatic and ecosystem science institutes however, we learned that despite regulations placed on waste water effluent, triclosan, among other chemicals in our consumer products, is still released into the environment and these environmental levels are in fact harming aquatic organism health.



Aquatic organisms are particularly at risk because they are constantly subjected to triclosan (in addition to other toxic chemicals) in wastewater effluent, thereby making their exposure more chronic in nature. However the current body of knowledge is disproportionally focused on the acute toxicity of triclosan. There is a need to better understand these long-term effects on aquatic organism health, but this is difficult because the effects of the parent compound as well as the transformation products are often insidious and slow acting.

To manage the risk of triclosan SFEI is pursuing source control measures: “encouraging less consumer usage of triclosan-containing antimicrobial hand soaps and other consumer products.”[4]

Sources:
[1] Davis, Jay. "Triclosan." *Cec Monitoring* (2013): n. pag. *SFEI*. Web.
[2] "Contaminants of Emerging Concern Strategy." *SFEI*. 2013. Web.
[3] Veldhoen N et al. 2006. The bactericidal agent triclosan modulates thyroid-associated gene expression and disrupts postembryonic anuran development. Aquatic Toxicol. 80: 217–227.
[4] For Water Quality In The San Francisco Estuary. "Triclosan." *Contaminants of Emerging Concern* (2011): *RMP*. Apr. 2011. Web.

Our conversations with **Bruce Hammock**, a National Academy Member for his work in environmental toxicology, highlighted the need to approach the issue of chemical regulation responsibly.

Even Dr. Hammock, who has authored a number of papers calling attention to the risks associated with triclosan's use, made a point to tell us that in some applications, triclosans use is justified and that appropriate vs. inappropriate chemical use is largely dependent on the context of application.

For instance, triclosan actually plays a very useful role in surgical scrubs by removing the last 1% of bugs that soap won't remove but that this extra bit of killing power is not needed in everyday use.

Hammock talked about how society too often panics into decisions regarding chemical use: citing a pattern of how chemicals will be used for some time before research on its harmful effects emerge. Soon after, however, citizens panic and try to remove its use altogether: failing to acknowledge that its not chemicals themselves that are evil, but rather their overuse that is harmful. Hammock cautioned us against playing into this fear and instead suggested we urge for more prudent use.

Arlene Blum, founder of the Green Science Policy Institute, highlighted the incongruity in evaluating chemical toxicity/risks on an individual basis when chemicals interact with other chemicals – oftentimes synergistically – in the environment. To that end, Green Science Policy Institute categorizes and evaluates chemicals in 6 main classes: highly fluorinated chemicals, flame retardants, bisphenols & phthalates, organic solvents, metals, and antimicrobials.

To expound further on the utility of a 'class' approach, Blum explained how when chemicals are removed from use, manufacturers look for a replacement; but because these chemicals need to serve similar functions, they often have similar structures, and thus similar consequences. What results is a cycle whereby one toxic chemical is replaced by another toxic chemical.

Blum aims to stop this cycle and reduce the overall use of toxic chemicals in consumer products by targeting the elimination of these classes of chemicals where their use has no proven benefit. To do so Green Science Policy Institute works to inform manufacturers, retailers and consumers about where these classes of chemicals can be found, how they can

be avoided, and what alternatives might be available. Blum targets industry because by electing to phase a chemical out of their products, industry can have an enormous influence on the types and amount of chemicals that are released into our environment.

This approach has proven effective: Green Science Policy Institute provided much of the data that was instrumental in persuading furniture manufacturers to reduce their use of flame-retardants and in persuading policy makers to revise state furniture flammability standards.

*To more effectively manage risks experts are pursuing **source control** at the **consumer** and industry level. Experts have also expressed the need to **raise awareness** around appropriate use and to justify the use of these chemicals in products.*

From these conversations, we gathered that there are many "pressure points" for change regarding chemical use. To better understand what levers have been effectively pushed in the past to instigate change, we researched landmark chemical regulation cases.

III. Landmark Chemical Regulation Case Studies

When **DDT** first came out in the 1940s it was touted as a wonder-chemical: a safe and effective way to get rid of annoying bugs! As early as 1945 scientists began to uncover DDTs harmful effects on the environment and human health, but it wasn't until 1962, when Rachel Carson authored her seminal work "Silent Spring", that DDTs harmful effects were brought into the public eye. Much of the data that Carson drew from wasn't new, but what Carson's work did was **raise enough public awareness to pressure government to take legislative action.** In 1972, a ban was placed on its agricultural use in the US as well as its export.

Sources:
[1] Berry-Caban, Cristobal S. "DDT and Silent Spring: Fifty Years after." JMVH. Web. 18 Sept. 2015.
[2] "EPA." DDT Regulatory History: A Brief Survey (to 1975). N.p., n.d. Web. 18 Sept. 2015.
[3] "PG&E Hinkley Chromium Cleanup." Lahontan Regional Water Quality Control Board.. Web. 18 Sept. 2015.

Between the years 1952 and 1966, PG&E used hexavalent chromium (chromium 6) to prevent corrosion in the cooling towers of their compressor station located in the Mojave Desert. Some of this waste-water made its way into nearby bodies of water, including the town of Hinkley, leading to severe contamination of the water with carcinogenic hexavalent chromium. In a study conducted by PG&E, average hexavalent chromium levels in Hinkely were recorded as ranging from an average of 1.19 parts-per-billion (ppb) to a high of 20 ppb. The proposed California health goal for hexavalent chromium, as of 2011, as defined by the Office of Environmental Health Hazard Assessment is .02 ppb. [1] Citizen scientist/environmentalist Erin Brokovich was instrumental in calling legal attention to this issue.

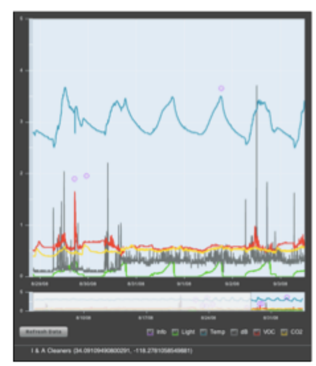
Sources:
[1] "PG&E Hinkley Chromium Cleanup." *Lahontan Regional Water Quality Control Board*. Web. 18 Sept. 2015.

The DDT and Chromium 6 case studies demonstrated how citizen scientist, with sound data, were instrumental in bringing chemical use issues into the public c eye and pushing for legislative action; and from talking to experts, we identified that raising awareness about appropriate chemical use can have a real impact. From these case studies and our conversations with experts, we identified civic engagement as an effective catalyst for change.

To figure out how to effectively raise public awareness we studied civic engagement initiatives and identified factors that made them successful.

IV. Civic Engagement Initiative Case Studies

From studying Professor Greg Niemeyer's Black Cloud initiative and Code for America's "Adopt a Fire Hydrant" initiative, we gathered that successful civic engagement initiatives **foster a sense of individual and collective responsibility** and **provide a sense of agency grounded in reality.**



For his project, **"Black Cloud,"** Professor Greg Niemeyer partnered with Andy Garcia, a high school teacher in LA to install twelve air quality sensors in the neighborhood around the school. The sensors transmitted data on levels of carbon dioxide and volatile organic compounds to a website that plots this data on air quality conditions in real time. Neimeyer made a point not to geotag the sensors. Instead, he invited students to connect the data on local air quality to the human behavior and uses of space that caused them – an exercise to bridge the mental disconnect between human behavior and local air quality.

The data galvanized students into action. At 600 parts per million carbon dioxide, LA is almost twice as polluted as the average place. But shockingly the sensors logged 3000 parts per million inside the classroom! Because the sensors logged data in real time, students saw how CO2 levels decreased when their classroom had better ventilation and decided to keep windows and doors open during the day. Being able to directly see their impact on their local environment encouraged the students to change their behavior and also empowered students with a sense of agency that extended beyond the classroom. Niemeyer noted that, "At the end of two months, [the students] are now pretty avid environmentalists, and more than that, they're really interested in protecting their health and making changes… in their neighborhood."[1]

Sources:
[1] Berg, Nate. "The Black Cloud: Using Games to Understand Air Quality." *Planetizen: The Urban Planning, Design, and Development Network*. 4 Sept. 2008. Web.

Code for America's **"Adopt a Fire Hydrant"** initiative highlights the role technology can play in forging a beneficial relationship between citizens and government, and effectively uses gamification to motivate user behavior.

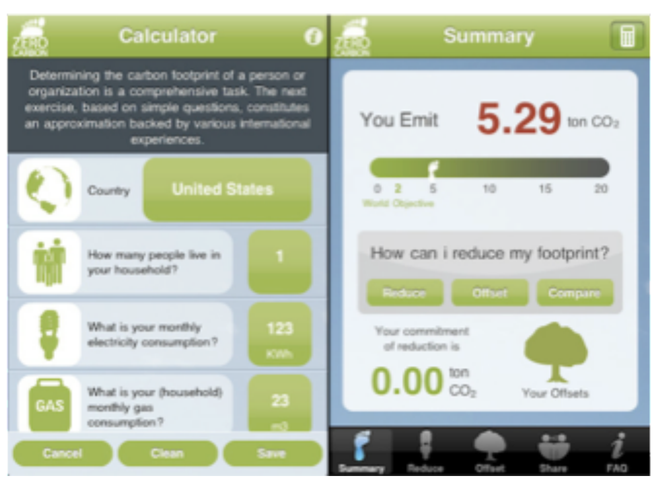
Code for America is an organization established in 2009 by Jennifer Pahlka to, "enlist technology and design professional to work with city government to create open source apps to promote openness, participation, and efficiency in government."[1] To illustrate the power of civic engagement, Phalua gives an example of a map based web app called "Adopt-a-Hydrant." The app was borne from the mind of Erik Michaels-Ober, a Code for America fellow based in Boston, who observed how in the winter-time, residents would shovel their own driveways, but neglect to shovel out fire hydrants. This is a problem because, "buried hydrants cause dangerous delays for fire fighters. But having City of Boston employees check and clear thousands of hydrants would be a timely, costly and burdensome process. 'Adopt-a-hydrant' lets governments look to community members for help."[3] Its a map-based web app that allows individuals, small businesses and community organizations to claim responsibility for shoveling out specific fire hydrants. And if they fell short of their promise someone else can "steal" the fire hydrant away from them.

This initiative was so successful in Boston that it has spawned similar initiatives in other states. Honolulu re-appropriated the idea to enlist the help of citizens to check on tsunami sirens, and similar initiatives were rolled out in Seattle for clearing out clogged storm drains, and in Chicago for shoveling out snow covered sidewalks. [2]

Sources:

[1] Pahlka, Jennifer. "Coding a Better Government." *Code for America.* Feb. 2012. Web.
[2] "About I Code for America." *TED*. Web.
[3] Ober, Erik Michaels. "Adopt-a-Hydrant I Code for America." *Code for America.* Web. 14 Sept. 2015.

What could work better: Calculate your carbon footprint apps



In her article, "Why you've never measured your carbon footprint," sustainable business consultant Mia Overall, lists the following shortcomings of carbon footprint apps:

- the final score is abstract: what does a ton of CO2 mean?
- "the questions are usually too general to detect most behavioral changes that can lower our environmental impact, such as changing light bulbs. This means that we miss getting the satisfaction of seeing our score improve." In other words, these apps

do not demonstrate to the user how changing their behavior would make an appreciable difference, so users are not encouraged to change behavior.
- “carbon footprint calculators generally fail to show us how we should be doing. What would a sustainable carbon footprint be and how does one get there? [carbon footprint apps] say surprisingly little about the behaviors needed to achieve a sustainable level.”

Overall then goes on to suggest some improvements that could be made. “People respond to metrics that seem relevant to us. We need specific targets and goals. We react to competition, want to be recognized for our accomplishments and need to be held accountable. The next sustainability apps should harness our ability to capture accurate personal data, our curiosity about how we are doing compared to others, and leverage social media to provide positive recognition, drive competition and offer rewards.”

These civic engagement case studies emphasized the need to think critically about how to craft technologies to actually inspire change. We kept these ideas in mind as we refined our project.

Sources:
[1] "Why You've Never Measured Your Carbon Footprint." *GreenBiz.* 18 Feb. 2014. Web.